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SELECTION AND BREEDING FOR HIGH YIELD IN COCONUT*

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The programmes of selection and breeding have been discussed. Substantial increases in yield may be obtained by selection of seed parents on weight of husked nuts, followed by a rigid selection of seedlings in the nurseries. The *tall* × *dwarf* (F_1) hybrid is recommended for those areas with light sandy soils and a good distribution of rainfall, although heterosis may be exploited fully only under good management.

INTRODUCTION

The estimated acreage under coconuts in Ceylon is 1.15 million acres of which 27 per cent i.e. 309,000 acres are in estates of over 50 acres in extent. The balance 73 per cent constitute small-holdings. The small holdings contribute about 53 per cent to the total production, although their yield may be as low as 1000-1500 nuts per acre.

The total production and exports of coconut for a six year period are given in table 1.**

TABLE 1

Year	*Total production (million)*	*Export (nut equivalent) (million)*
1964	3248	1618
1965	2681	1270
1966	2468	1017
1967	2421	940
1968	2642	1096
†1969	2616	906

**Report to the Food and Agriculture Organization of the United Nations for the period 1967-68 (Govt. of Ceylon).
†Annual Report of the Biometrician, Coconut Research Institute.

The decline in yield during the period 1965-1967 is thought to be due to unfavourable weather conditions. It would appear that production and exports are rather static, and this may perhaps be a reflection of the fact that a large number of estates and small-holdings are due for replanting. Furthermore, ever increasing domestic consumption of this commodity would seriously curtail exports.

As with most crops "production" is a result of the interplay of a number of factors and is reflected in (*a*) choice of planting material (*b*) use of adequate fertilizer and correct cultural practices, (*c*) pest and disease control and (*d*) the environment. The first factor will be discussed in this paper.

The programmes of research which are being implemented since 1940 aim to improve the quality of the planting material, largely through conventional breeding and selection techniques.

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SELECTION FOR HIGH YIELD

Uniform high yields, particularly in a crop like the coconut, which is out-breeding and with no known methods of vegetative multiplication, is a difficult target to achieve. Even in an apparently uniform group of palms, a glance at the individual yield records would show that a large percentage of the total crop is given by a few palms. Thus most of the palms are either average or below average yielders. The last group is uneconomical and tends to increase the overall cost of production. It may be possible to increase yields through a process of selective thinning whereby the below-average performers are removed and the vacancies replaced with high yielding planting material. One likely objection is the difficulty of maintaining livestock, particularly cattle, on land which is subjected to intermittent replanting. This is an important aspect which has to be borne in mind.

In view of the large acreage which is going out of effective production annually, due to senility of palms, rehabilitation of the industry by replantation is a long felt need, for it may not be possible to expand the present acreage under coconuts except in some marginal areas. As the economic life of a coconut palm extends for about 60 - 70 years, only the best planting material should be used for both replanting and new planting. From the results of a Selection Experiment, and Progeny Trials, it is evident that there is a marked response to selection of seedlings at the nursery stage, as well as to a selection of mother palms based on weight of husked nuts. Husked nut weight has a high heritability value (0.95, Liyanage and Sakai, 1960). Using the above criteria we have been able to improve the quality of the planting material and selected mother palms as a source of seed for the nurseries, thus superseded the practise of selection of "block nuts" for this same purpose. About 50,000 mother palms have been selected from 20 estates in the Puttalam, Chilaw-Negombo and Kurunegala Districts. This quantity is barely sufficient to meet the demands of the coconut industry. Furthermore, periodic re-selection is necessary to eliminate any palms that may deteriorate. The production and issue of seedlings at the Institute's nurseries is indicated below.

Year	*No. of seedlings*
1966	1,128,139
1967	1,415,727
1968	1,518,868
1969	1,472,184

The first Seed Garden for the mass production of improved seed was opened in 1955 (Liyanage, 1955, 1961). The progeny of 'paired-crosses' has been used for planting a large area of the Seed-Garden. It is now necessary to identify palms of high-breeding value from within the seed garden which will serve as the only source of pollen for natural crossing with emasculated, phenotypically superior palms. In this regards, besides the conventional (and time consuming) method of progeny testing, Liyanage (1967, 1969) has suggested leaf production of the progeny and embryo-weight on self-pollination as useful indices in the identification of palms of high-breeding value..

INTER-VARIETAL HYBRIDIZATION

Increase in yield may be obtained by the use of improved strains. Hybrid maize was the first great 'success story' in the wide scale use of heterosis, first in the United States and then in Latin America.

Only one species, (namely *nucifera*) is recognized in the genus *Cocos*. Thus hybridization has necessarily to be intra-specific, (inter-varietal) and is therefore devoid of much of the glamour attached to inter-specific or intergeneric hybridization programmes.

The varieties and forms of the coconut grown in Ceylon have been classified into 3 broad groups (Liyanage, 1958)—The cross pollinating *typica* variety and the self-pollinating *nana* and *aurantiaca* varieties. Hybridization work on coconut commenced in 1950, and the initial work was mainly concerned with crossing the available *forms* of each of the above varieties in as many combinations as possible. Since then, techniques have been devised to store pollen for at least 12 months, (Manthriratna, 1955), and this has enabled us to expand our programme and also assist the private sector in this work. As the Coconut Research Institute cannot take upon itself the task of producing all the hand pollinated material required for the industry, one solution may be the operation of Certified Seed Companies, under close supervision by the Institute. Table 2 gives a summary of the number of female flowers pollinated and nuts harvested during the period 1965-1969, at the Institute's pollination stations.

TABLE 2

	1965		1966		1967		1968		1969	
	T×T	T×D	T×T	T×D	T×T	T×D	T×T	T×D	T×T	T×D
No. of female flowers pollinated	25469	12659	55168	nil	87372	nil	166700	nil	112729	53525
No. of nuts harvested	9240	391	8336	2927	16033	nil	19609	5505	23608	14578

(*T* × *T* = *tall* × *tall* "prepotent"; *T* × *D* = *tall x dwarf*)

Furthermore, during the above period 62,100 natural cross *dwarf* × *tall* hybrid seed was harvested from the Seed Garden, Ambakelle.

Two promising strains of coconut have been developed by the Institute :—

(*a*) CRIC 60 *tall* × *tall* ('prepotent')—late flowering high-yielding, tall in habit.

(*b*) CRIC 65 *tall* × *dwarf*—early flowering, high yielding and tall in habit.

CRIC 60 is suitable for all areas where coconut can be cultivated. The CRIC 65 (*tall* × *dwarf* or *dwarf* × *tall*) hybrid is by far the more spectacular performer, and this will be discussed at length.

The 22 F_1 progeny (from the earliest crosses done in 1950) has consistently given very high yields (Table 3).

TABLE 3

Yield of *tall* × *dwarf* (F_1) progeny
Mean yield per palm

Year		*Nuts*	*Weight of husked nuts (lb.)* total	wt. per nut
1959	(9th year)	103	147.8	1.43
1960		102	187.7	1.84
1961		129	225.6	1.75
1962		144	284.1	1.97
1963		165	297.9	1.80
1964		151	276.7	1.83
1965		180	295.8	1.64
1966		171	262.2	1.53
1967		135	202.9	1.50
1968		120	181.8	1.51
1969	(19th year)	135	210.8	1.56

The fall in yield during 1967-1969 may be largely attributed to weather conditions. Besides the yield, early flowering and rate of leaf production are two important characters in this hybrid. On further experimentation it was observed that 87 per cent of CRIC 65 flowered in under $3\frac{1}{2}$ years when compared with 19 per cent of the ordinary *tall* variety, so that the first crop from these hybrids can be gathered in the *fifth* year.

In the coconut palm an inflorescence is usually borne in each leaf axil, and therefore increase in leaf production may mean more bunches per year. The total number of leaves produced at 36 months in seedlings of the F_1 generation of (*a*) *tall* × *dwarf* (*b*) *tall* × *tall* and (*c*) *tall* open-pollinated have been studied, (Table 4).

TABLE 4. LEAF PRODUCTION

Treatment	*Total no. of leaves produced per plant in 36 months*
A. F_1 of *tall* × *dwarf*	27.22 ± 0.56
B. F_1 of *tall* × *tall*	24.31 ± 0.56
C. *Tall* open-pollinated	23.55 ± 0.56

Differences between treatments were significant ($P < 0.01$). Treatment A was significantly better than treatments B and C, and differences between the latter were not significant. The *tall* × *dwarf* hybrids thus have a higher rate of leaf production. In the field, these have been observed to have appreciably longer leaves and leaflets as well as sturdier trunks, these being the vegetative manifestations of hybrid vigour. These hybrids do not release their full potential under poor management; age of first flowering and yields are retarded. It is therefore proposed to study the fertilizer requirements of these hybrids in conjunction with the Soil Chemistry Division.

It is perhaps unfortunate that a critical assessment of these hybrids has not been made in all the Planting Districts, over a wide range of soil types and climate. Substantial quantities of this material have been issued to the industry since 1960, but we cannot evaluate the performance, as the response to a questionnaire requesting data on flowering and yield has been very poor.

Although attention has been focussed on the merits of *tall* × *dwarf* F_1 hybrids, it needs to be emphasised that the reciprocal *i.e. dwarf* × *tall*, is equally good. The oldest *dwarf* × *tall* hybrids (which were the result of random cross pollination of the *dwarf* variety) have performed exceptionally well for the past 30 years, (Table 5).

TABLE 5

Frequency distribution of natural hybrids (female parent pure dwarf) in the Dwarf Palm Block, Ratmalagara Research Station

Nuts per year	*Yield of nuts* *Frequency of palms in each yield class*	
	1961 – 1964	1965 – 1968
≤ 20	0	1
21 — 40	2	1
41 — 60	3	8
61 — 80	9	11
81 — 100	15	21
101 — 120	18	22
121 — 140	27	17
141 — 160	11	6
≥ 161	3	3
Mean yield/palm/year	112	99
Per cent palms yielding > 80 nuts	84	78

The variety dwarf green (variety *nana* form *pumila*) has been largely used in the production of *tall* × *dwarf* hybrids, and this choice was mainly due to the fact that this flowers in a shorter period compared with the form *regia* (dwarf red) and form *eburnea* (dwarf ivory-yellow). However, in Jamaica, 'Malayan' dwarf red is widely used for the production of hybrids and Whitehead *et al.* (1964) consider this to be a useful genetic marker. This aspect is being studied by us, for a genetic marker will be a useful criterion in selection, for at present we have to rely almost entirely on vigour of seedlings in screening *dwarf* × *tall* hybrids from pure dwarfs.

REFERENCES

Liyanage, D. V. 1955 *Rep. Cocon. Res. Inst. Ceylon* 38.

Liyanage, D. V. 1958 *Ceylon Cocon. Quart.* 9, 1.

Liyanage, D. V. 1961 *Ceylon Cocon. Quart.* **12**, 121.

Liyanage, D. V. 1967 *Expl. Agric.* **3**, 205.

Liyanage, D. V. 1969 *Ceylon Cocon. Quart.* **20**, 161.

Liyanage, D. V. & Sakai, K. I. 1960 *J. Genet.* **57**, 245.

Manthriratna, M. A. P. P. 1965 *Ceylon Cocon. Quart.* **16**, 102.

Whitehead, R. A., Thompson, B. E. & Williams, L. V., 1964. In *Report on 2nd Session of FAO Working Party on Coconut Production Protection and Processing, Colombo, Ceylon*, Rome : FAO.